CLAIMS

1. A pulse transit time-based method for distance measurement comprising the steps of:

setting initial components for a vector of parameters defining modulation of sent pulses;

emitting a pattern of said sent pulses toward a target according to said vector of parameters;

receiving a pattern of received pulses reflected from the target;

evaluating observability of pulse transit time through analysis of patterns of said sent and received pulses;

obtaining a pulse transit time measurement through the analysis of said patterns of said sent and received pulses if said evaluation is satisfactory;

calculating sought distance by taking said pulse transit time measurement as an input if said evaluation is satisfactory;

performing a correction on the components of said vector of parameters of modulation of said sent pulses if said observability evaluation is not satisfactory; and

returning to said emitting a pattern of modulated pulses step of said method, thereby providing an effective protection against disturbances that affect the process of measurement.

2. A method as claimed in claim 1 wherein:

said vector of parameters of said sent pulses' modulation controls the process of modulation such that any kind of modulation of sent pulses is available including but not limited to pulse-coding with a variable duty factor and/or duration of pulses, amplitude, frequency or phase modulation or any possible combination thereof; and

said modulation of said sent pulses produces specific areas on said pattern of received pulses such that a retrieval of said pattern of received pulses' characteristic variables that are functionally relating to said pulse transit time becomes possible under exposure to any passive and/or active disturbances existing in a measuring cycle; and

the physical origin of said pulses is application-dependent including but not limited to acoustic, electromagnetic and light waveforms; and

said pattern of sent pulses is a sequence of pulse bursts; and

the minimal number of the pulse bursts in said sent pulses is equal to one; and

the maximal number of the pulse bursts in said sent pulse could be a predetermined number or could be set in each or in some measuring cycles according to said vector of parameters of sent pulses; and

the minimal number of pulses in said pulse burst is one and;

The maximal number of pulses in said pulse burst could be a predetermined number or could be set in each or in some measuring cycles according to said vector of modulating parameters of sent pulses.

3. The method as claimed in claim 1 having said pulse transit time observability evaluated, further including:

forming a first vector of characteristic variables that are associated with said pattern of sent pulses and defined by current values of said vector of parameters of sent pulses;

forming a second vector of said characteristic variables that are associated with said pattern of received pulses and defined by current values of said vector of parameters of sent pulses;

creating a relation of characteristic variables that are the components of said first and said second vectors of characteristic variables;

evaluating the observability of said pulse transit time through the analysis of functional dependencies in said relation;

generating an indicator variable showing if said pulse transit time observability is satisfactory or not satisfactory.

4. The method as claimed in claim 3 wherein:

said indicator of pulse transit time observability is equal to the number of functionally dependent pairs in said relation of characteristic variables that are derived from said patterns of sent and received pulses and are presented as the components of said first and second vectors;

5. The method as claimed in claim 3, further including:

evaluating said pulse transit time observability by comparing said indicator of transit time observability with a positive reference value such that if said indicator of observability is greater or equal to said reference value, then said pulse transit time observability is considered satisfactory; otherwise, said observability is considered unsatisfactory.

6. The method as claimed in claim 5, having evaluated said observability of said pulse transit time at the current measuring cycle, for the sake of said method enhancement further including:

predicting the direction of change in the forthcoming value of said observability indicator with respect to said observability indicator's reference value such that if said indicator of observability is predicted greater or equal to said reference value, then said pulse transit time observability is considered satisfactory in the next measuring cycle; otherwise, said observability is considered unsatisfactory in the next measuring cycle.

7. The method as claimed in claim 1 wherein:

said pulse transit time observability evaluation may include non-forecasting techniques or forecasting techniques or combination of both forecasting and non-forecasting techniques depending on the specifics of said method's application.

8. The method as claimed in claim1 having said pulse transit time measured, further including:

measuring said pulse transit time in each measuring cycle by capturing a time-position of one or more than one characteristic variables that are derived from said patterns of pulses if said pulse transit time observability is satisfactory.

9. The method as claimed in claim 8 wherein:

said characteristic variables of the patterns of sent and received pulses may include but not limited to the components of said first and said second vectors of characteristic variables and;

said characteristic variables of the patterns of sent and received pulses possess the property of low sensibility to disturbances affecting the process of measurement.

10. The method as claimed in claim 9 wherein:

in one method's embodiment utilizing the frequency modulation of said emitted pulses, said first vector of characteristic variables includes among the coordinates of said vector a timestamp associated with the time instance when the carrier frequency changes and;

said second vector of characteristic variables includes among the coordinates of said vector a timestamp associated with the time instance when the carrier frequency changes.

11. The method as claimed in claim 8, for the sake of said method enhancement, further including:

determining in the current measuring cycle the segments on said pattern of received pulses that are affected by disturbances;

predicting for the next measuring cycle the position of the disturbed segments on said pattern of received pulses;

blocking in the next measuring cycle the pulse transit time data collection from those segments on said pattern of received pulses that have been predicted being disturbed in the next measuring cycle.

12. A method as claimed in claim 1 wherein:

said pulse transit time measurement may include non-forecasting techniques or forecasting techniques or combination of both forecasting and non-forecasting techniques depending on the specifics of said method's application.

13. The method as claimed in claim 1 wherein:

in one method's embodiment the true pulse transit time measurement is distinguished from the false pulse transit time measurement by requiring that in any measuring cycle the number of emitted pulse bursts must be greater or equal to the number of received echo pulse bursts and;

in another method's embodiment the true pulse transit time measurement is distinguished from the false pulse transit time measurement by requiring that in any measuring cycle the number of emitted pulse bursts is equal to the number of received echo pulse bursts and the sampling time for collecting the echo-pulse bursts is in the neighborhood of the sent pulse-code time that includes the predetermined number of consequent pulse bursts.

14. The method as claimed in claim 1 wherein:

in another method's embodiment the single pulse-burst's duration and the single pulse burst's duty factor are as such that a fusion of separate echo-pulses occurs producing a single, continuous within its duration, pattern and;

the true pulse transit time measurement is distinguished from the false pulse transit time measurement by requiring that in any measuring cycle the number of extreme values present on said echo pattern's envelope is in a relation to said number of pulse bursts existing in said pattern of sent pulses and;

the time distance between the two consequent likewise extreme values existing on said pattern of received pulses is within a neighborhood of the period of the corresponding pulse burst on said pattern of sent pulses;

15. The method as claimed in claim 14, wherein:

in one method's embodiment, said fused continuous on its period echo-pattern is achieved by requiring that said single pulse's period and a gap between the two consequent pulses are smaller than the sum of a pulse emitting unit transient time and a processing hardware transient time and;

in another method's embodiment, said fused continuous on its period echo-pattern is achieved by requiring that said single pulse burst's period and a gap between the two consequent pulse bursts are smaller than the sum of a pulse emitting unit transient time and a processing hardware transient time.

16. The method as claimed in claim 14, wherein:

for said pulse transit time observability evaluation, a set of characteristic variables of said pattern of received pulses is established and;

said set includes in its membership but not limited to (a) maximums and minimums existing on said pattern, (b) relationship between at least one of said pattern's extreme value and one of its opposite extreme value, (c) relationship between at least one of said pattern's extreme value and its another likewise extreme value and;

said characteristic variables could be comprised of adjacent extreme values existing on said pattern of received pulses or could be comprised of extreme values that are not adjacent in their position on said pattern of received pulses.

17. The method as claimed in claim 14, wherein:

in one method's embodiment, a value of at least one minimum of said pattern of received pulses is used for distinguishing said true pulse transit time measurement from said false pulse transit time measurements, whereby providing protection against possible saturation of said pattern of echo pulses.

18. The method as claimed in claim 1, having performed said correction on the parameters of sent pulses modulation, further including:

altering at least one component of said vector of parameters of modulation such that said pattern of sent pulses in some forthcoming measuring cycle differs from said pattern of sent pulses existing in the current measuring cycle.

19. An apparatus for distance measurement comprising:

means for generating and sending a pattern of send pulses toward a target;

means for receiving a pattern of received pulses reflected at the target;

means for computing and controlling that receive, process, transfer and exchange information between the parts of said apparatus and between said apparatus and the environment; and

means for modulating said send pulses to minimize effect of distances during measuring process.

20. The apparatus as claimed in claim 19, wherein:

said computing means include a plurality of hardware and software elements meant for the implementation of functions of analyzing the process of distance measurement, altering said sent pulses modulation and controlling the process of distance measurement in accordance with said method for distance measurement and;

said function of analyzing the process of distance measurement is attributed to Analyzer-unit of said computing means and;

said function of altering said sent pulses modulation is attributed to Corrector-unit of said computing means and;

said function of controlling the process of distance measurement in accordance with said method for distance measurement is attributed to Controller-unit of said computing means.

21. The apparatus as claimed in claim 19, wherein:

said means for generating and sending said pattern of pulses are comprised of a plurality of functional elements including Former, Timer, Driver and Emitter, and;

Former, whose enable input is connected to said Controller's initiating output, and whose digital input bus is connected to said Controller's digital output bus, and whose control output bus is connected to the driving point bus of said Driver, converts said Controller's vector of pulse modulating driving signals into said Driver's control output bus and;

Timer, whose enable input is connected to said Former's synchronizing output and whose output is connected to said Former's complementing input, supports the timing of said Driver's control signal initiation and;

Driver, whose output is connected to the excitatory input of said Emitter, being controlled by said Former, provides an excitatory signal to Emitter and;

Emitter emits said pattern of pulses toward said target.

22. The apparatus as claimed in claim 19, wherein:

said means for receiving said pattern of pulses reflected at the target are comprised of a plurality of functional elements including Receiver and Amplifier, and;

Receiver receives said pattern of echo pulses and sends said pattern of echo pulses for an amplification through said Receiver's output connected to the input of said Amplifier and;

Amplifier whose output is connected to the analog input of the Analyzer unit of said computing and controlling means, provides initial echo-signal processing that includes at least the amplification of said pattern of received pulses.

23. The apparatus as claimed in claim 19, wherein:

said Analyzer whose analog input is connected to said output of Amplifier, performs computing operations that include but not limited to (a) creating a relation of characteristic values derived from said patterns of send and received pulses; (b) comparing pairs of variables in said relation and identifying the true pulse transit time measurement; (c) evaluating said observability of said pulse transit time variable and;

said Corrector whose digital input bus is connected to Analyzer's digital output bus and whose digital output bus is connected to Controller's digital input bus, performs computing operations that include but not limited to calculating corrections of said emitted pulses modulating parameters based on the result of said pulse transit time observability evaluation provided by Analyzer, and generating a vector of parameters that identify the modulation of said emitted pulses, and delivering said vector of modulating parameters to Controller through said Corrector's output digital bus and;

said Controller whose digital input bus receives said vector of corrected modulating parameters from said Corrector that sends said enabling signal to said Former and whose digital output bus sends to said Former said vector of driving signals with a mask of said modulating parameters and whose global output contains the sought distance performs computing operations that include but not limited to generating said vector of driving signals controlling said sent pulses modulation, calculating said sought distance based on said pulse transit time measurement and interfacing the measured distance out for further utilization.

24. The apparatus as claimed in claim 19, wherein:

any digital input bus or digital output bus allows its hardware or software or combined hardware and software implementation and;

said bus represents a functionality of vectorial data communication within said computing and controlling means and other functional units of said apparatus.

25. An apparatus for distance measurement comprising:

means for generating and sending a pattern of send pulses toward a target;

means for receiving a pattern of received pulses reflected at the target;

means for computing and controlling that receive, process, transfer and exchange information between the parts of said apparatus and between said apparatus and the environment; and

means for evaluating observability of pulse transit time through analysis of patterns of said sent and received pulses.